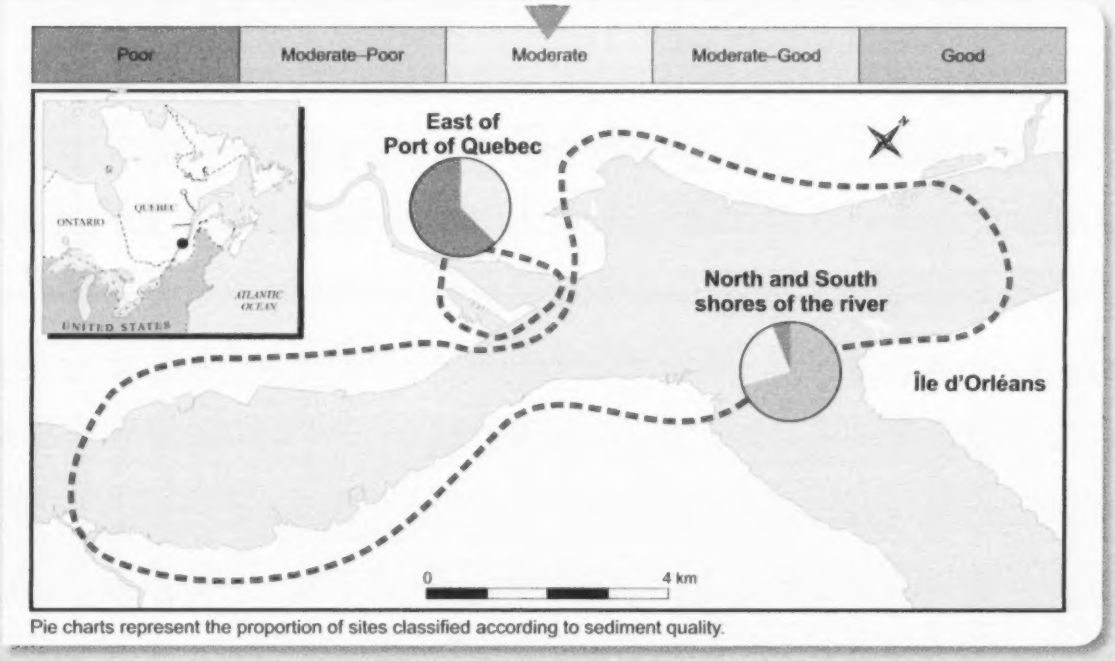
Monitoring the State of the ST. LAWRENCE RIVER

SEDIMENTS | WATER | SHORELINES | BIOLOGICAL RESOURCES | USES

Sediment quality in the St. Lawrence River in the Quebec sector in 2012 and its evolution since 1989

Status: The sediment quality of the St. Lawrence near Quebec City is considered moderate in 2012.

Evolution: Although the overall situation has improved since the end of the 1980s in the north and south shores of the river, the eastern sector of the Port of Quebec remains contaminated by metals, hydrocarbons and butyltins.



Pie charts represent the proportion of sites classified according to sediment quality.

Figure 1: Territory under study and environmental problematic related to sediment contamination in the St. Lawrence River in the region of Quebec

Canada

ST. LAWRENCE Action Plan 2011-2026

Québec

Problematic

The cities of Quebec and Lévis are the two main urban conurbations on the shores of the St. Lawrence River's fluvial estuary, which extends from Trois-Rivières to the eastern point of île d'Orléans. The region includes the Port of Quebec, an important deep-water port on the north shore, a shipyard (Chantier Davie Canada Inc.) and a petroleum wharf for the Jean-Gaulin Refinery on the south shore. The average flow of the river in this area is approximately 12 300 m^3/sec and the amount of suspended matters in water varies between 10 and 15 mg/L. The tide can reach up to 6 metres.

The assessment of sediment quality throughout the study area revealed a significant contamination problem in a few specific locations. Environmental issues concerning sediment quality are mainly related to urban and industrial discharges, causing contamination by metals and hydrocarbons.

Status in 2012 and evolution since 1989

The chemical quality of sediments in the Quebec City area was analyzed by Environment Canada in 1989 as part of a comprehensive characterization program for federal sites in Quebec. In 2012, a new sampling campaign has been carried out in order to determine the status and evolution of sediment quality.

The results are presented for the sector East of the Port of Québec, which includes the Louise Basin and the estuary of the Saint-Charles River, and for the North and South shores sector, including the shipyard, the petroleum wharf, the Beauport Bay and the other port areas. In 2012, the status with regard to sediment quality is considered globally as moderate for the whole territory. However, the sector East of the Port of Quebec presents higher indexes of contamination than elsewhere (figure 1).

Average concentrations measured and sediment quality criteria*
(TEL : Threshold effect level, OEL : Occasional effect level)

Note : the numbers in red indicate an exceedance of the TEL

	Quality criteria*		North and South shores of the river		East of the Port of Quebec	
	TEL	OEL	1989	2012	1989	2012
Arsenic (mg/kg)	5.9	7.6	1.17	3.17	2.68	4.49
Cadmium (mg/kg)	0.6	1.7	1.37	0.17	2.01	0.90
Chromium (mg/kg)	37	57	16.5	18.6	27.4	34.0
Copper (mg/kg)	36	63	15.9	16.4	41.5	98.1
Mercury (mg/kg)	0.17	0.25	0.07	0.03	0.17	0.14
Nickel (mg/kg)	--	47	12.3	19.5	18.4	54.8
Lead (mg/kg)	35	52	16.4	8.8	46.1	34.2
Zinc (mg/kg)	120	170	73.8	74.2	246.2	302.0
Metal Index	**1**	**1.6**	**0.74**	**0.42**	1.60	1.54
Metal index variation (%)				**-43.12**		**-3.55**
PAHs						
Acenaphtylene (ng/g)	5.9	30	1.7	4.0	2.7	32.8
Acenaphtene (ng/g)	6.7	21	3.2	2.9	2.2	22.0
Anthracene (ng/g)	47	110	24	8	49	69
Benzo(a)anthracene (ng/g)	32	120	49	31	33	197
Benzo(a)pyrene (ng/g)	32	150	9	24	23	166
Chrysene (ng/g)	57	240	38	51	42	259
Dibenzo(ah)anthracene (ng/g)	6.2	43	3.2	6.4	7.5	42.7
Fluoranthene (ng/g)	110	450	90	70	110	360
Fluorene (ng/g)	21	61	4	6	12	36
Naphthalene (ng/g)	35	120	3	5	7	22
Phenanthrene (ng/g)	42	130	70	24	120	222
Pyrene (ng/g)	53	230	136.2	55.7	95.8	302.6
PAH index	1	**3.1**	1.23	**0.68**	2.60	4.38
PAH index variation (%)				**-44.54**		**+68.48**
Tot. PCBs (ng/g)	34	79	14.8	14.7	68.4	71.1
PCB variation (%)				**-0.63**		**+3.94**
Butyltins (ng Sn/g)**	5	20		3.5		29

* EC et MDDEP 2007 ** Pelletier et collaborateurs, 2014

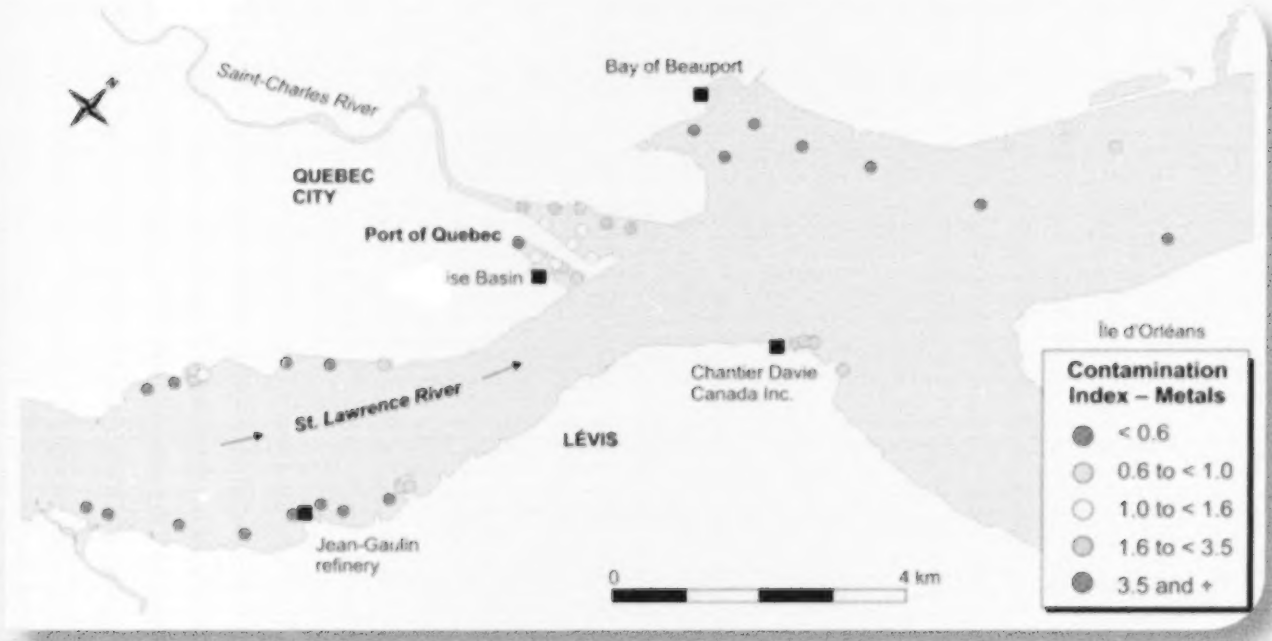


Figure 2: Index of sediment contamination by metals in 2012

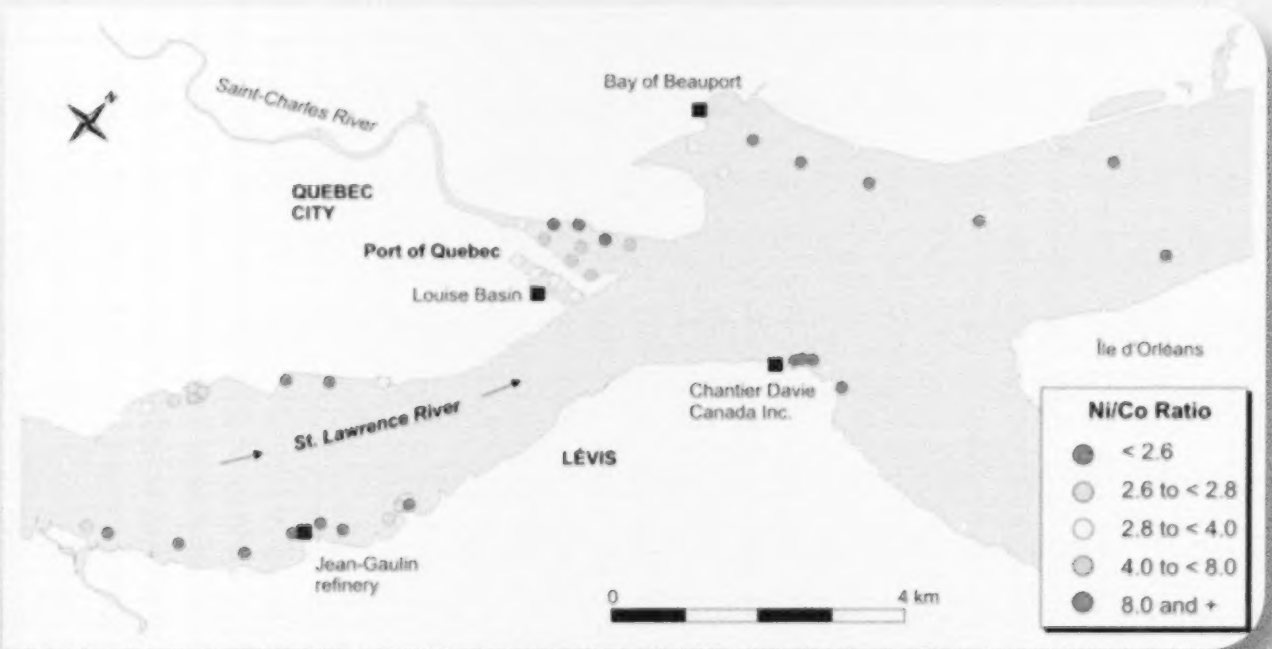


Figure 3: Ratio of nickel and cobalt in sediment in 2012

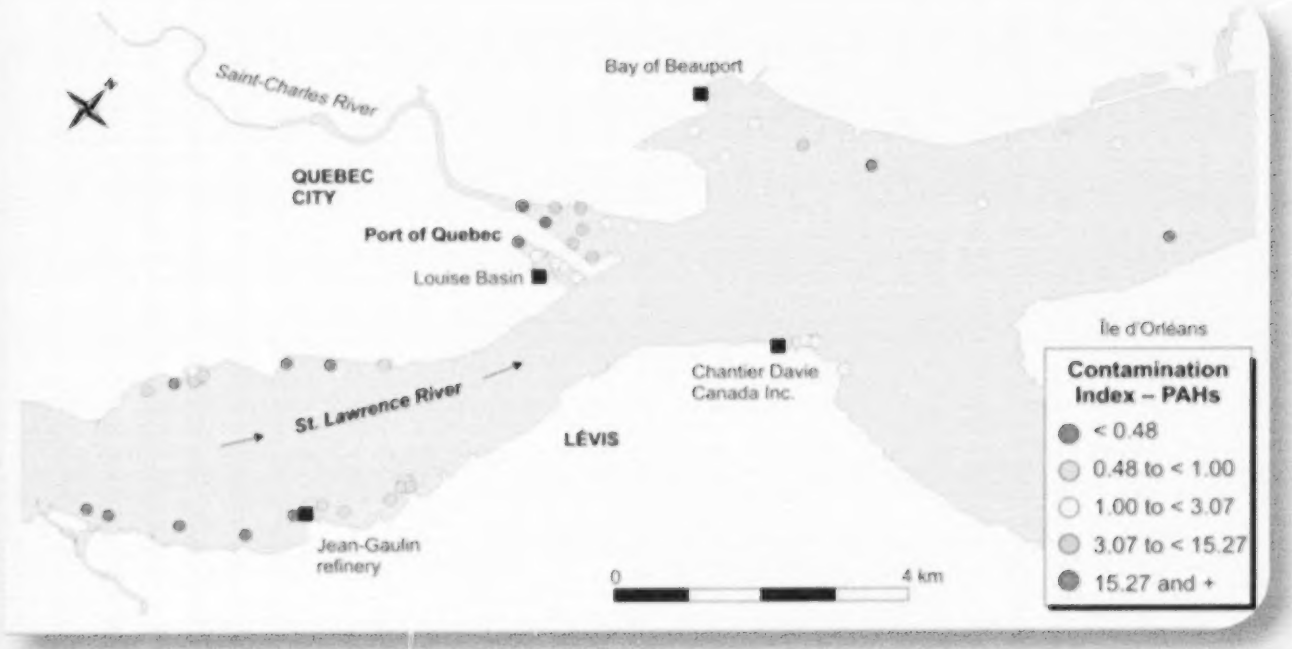


Figure 4: Index of sediment contamination by PAHs in 2012

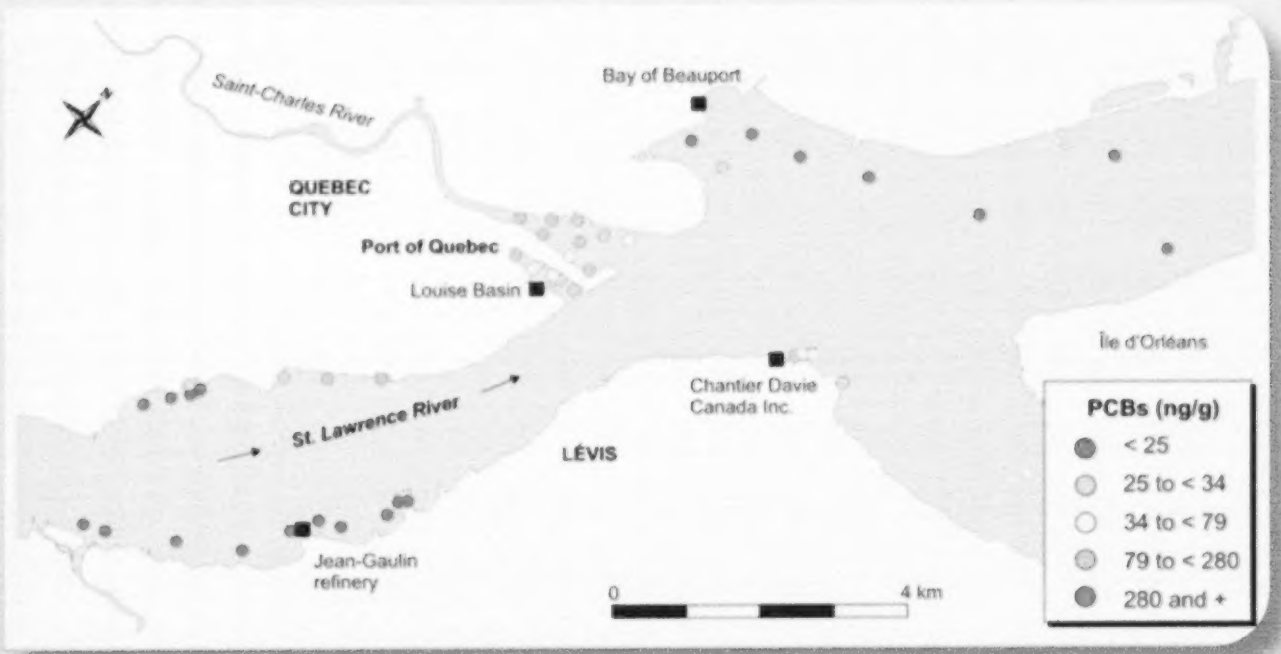


Figure 5: Concentrations of PCBs in sediment in 2012

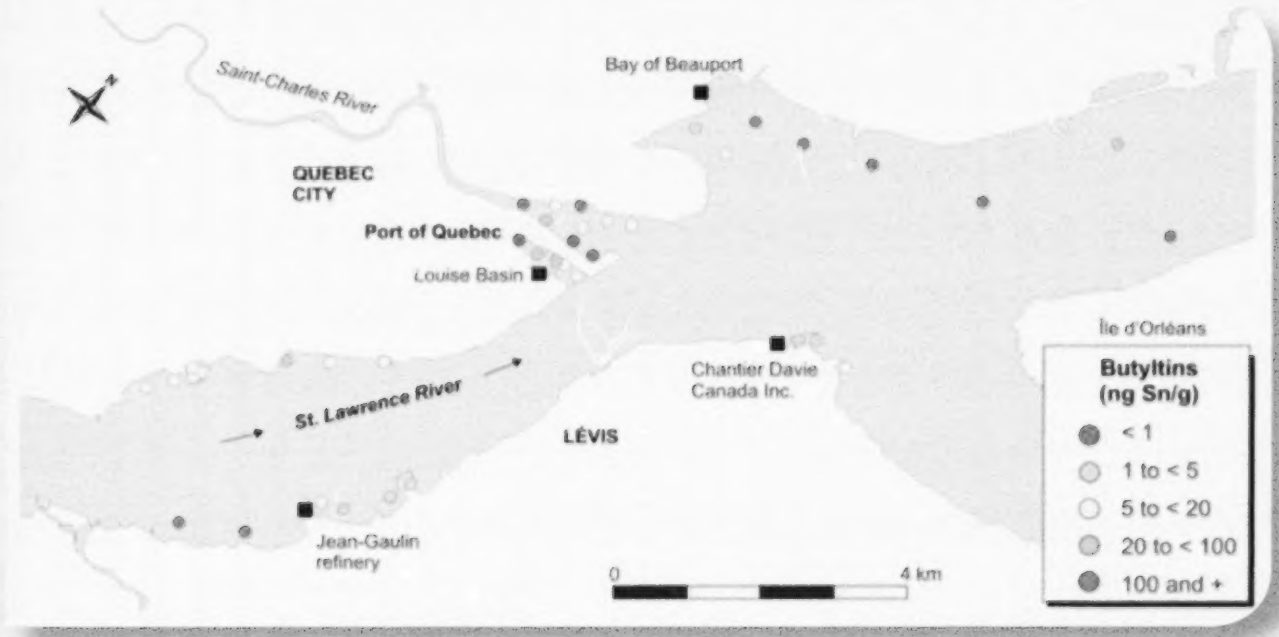


Figure 6: Concentration of butyltins in sediment in 2012

Sector East of the Port of Quebec

Status: In 2012, the sediment quality is moderate-poor. Indeed, 64% of sampled sites are considered very contaminated and 36% are considered contaminated (figure 1). The Louise basin and the estuary of the Saint-Charles River are the most contaminated sectors of the region of Quebec since 1989. Overall, metal concentrations are generally above the TEL criteria (see "Indexes and quality criteria for sediment") and sometimes even exceed the OEL criteria, which is higher for Quebec sediment quality assessment criteria (EC and MDDELCC, 2007). In the case of organic substances, the mean concentration of PCB exceeds the TEL (table 1 and figure 5). Concentrations of butyltins are elevated and deemed of concern.

Evolution: The sediment quality index for metals shows little variation (1.60 in 1989 compared to 1.54 in 2012). Although cadmium, mercury and lead are observed to decrease, concentrations for other metals (copper, zinc and nickel) show an increase. The average concentration of nickel has greatly increased from 18.4 to 54.8 mg/kg during that period. This icrease seems to be related to the transshipment of the nickel ore at the Port of Quebec because of the elevated ratio of nickel versus cobalt observed there (figure 3), which is characteristic of the ore (Saint-Louis et al. 2014).

The average concentration of PCBs in 2012 is 71 ng/g, which is more than twice the TEL. It remains although stable since 1989. Concentrations of PAHs have increased greatly during that period because the sediment quality index for PAHs has climbed by more than 68% (table 1). Indeed, the average concentration of the twelve PAHs considerred has icreased. Except for naphthalene, average concentrations of all the PAHs exceed the TEL and seven of them also exceed the OEL. The increase in PAHs is important in the estuary of the Saint-Charles River. The potential source causing such an increase in concentrations of PAHs has not been identified. It is possible that it originates from the accidental discharges of hydrocarbons, industrial activities or from the occasional opening of the Joseph-Samson dam located just upstream of the estuary of the Saint-Charles River in order to purge undesirable sediment from it.

For butyltins, the three samples studied by Regoli (2001) collected from this sector showed a very high average of 1539 ng Sn/g. The average concentration measured in 2012 is now of 29 ng Sn/g, with concentrations still very elevated of 1218, 423 and 479 ng Sn/g. Therefore there appears to be a decreasing trend, but one must be cautious with this comparison because the average concentration in 1998 was linked to few samples and the sampling techniques may have differed from those used by Environment Canada in 2012.

Sector North and South shores of the river

Status: In 2012, the sediment quality is moderate-good. 70% of sampled sites are considered to be slightly or not contaminated, 23% are considered contaminated and 7% are considered very contaminated (figure 1). Concentrations of metals measured in 2012 were below the TEL in 88 % of samples. As for organic substances, average concentrations of the twelve PAHs are lower or slightly higher than their respective quality criteria (TEL) (table 1). Average concentration of PCBs is low and below the TEL. Finally, the average concentration of butyltins is low and below the criteria of 5 ng Sn/g.

Evolution: Overall, the sediment quality index for the set of metals considered shows a 43% decrease between 1989 and 2012. This demonstrates that concentration has decreased significantly. The overall concentration of the set of twelve PAHs considered has also decreased significantly. Indeed, the sediment quality index for PAHs has tumbled by close to 45%. The average concentration of PCBs has remained stable since 1989, well below the TEL with an average concentration of 14.7 ng/g in 2012. As for the average concentration of butyltins, it appears to have decreased greatly based on the work of Regoli (2001), going from 472 ng Sn/g to 3.5 ng Sn/g. The same caution is needed comparing these data, but we can still conclude that the situation has improved and that the trend towards the decline observed is also logical, since the use of TBT products in the maritime environment (mainly anti-fouling paints for boat hulls) is forbidden in Canada since 2002.

Conclusion

The Louise basin and the estuary of the Saint-Charles River remain the most contaminated sectors. The situation does not seem to have improved since 1989 and has even deteriorated in the case of PAH contamination. The environmental impact of this contamination is, however, limited because the sediments are confined there due to currents and site configuration (PASL, 1993). In the perspective of sediment management, it is recommended to carry out in-depth studies for potential dredging works in these sectors.

As for the riparian sectors of the river, the situation has improved globally. The concentration of the set of metals has decreased since 1989, as well as those of PAHs and butyltins.

Indexes and quality criteria for sediment

The sediment quality criteria reported in this document (TEL: threshold effect level, OEL: Occasional effect level) are taken from EC and MDDEP (2007). They are defined according to the biological effects observed on benthic and pelagic organisms and the concentrations of contaminants measured in sediments

The quality indexes are calculated for each substance in each sample by dividing the measured concentration by its TEL quality criterion. An index greater than 1 indicates that the content exceeds the criterion and effects may be observed on the organisms, while a value of less than 1 shows good quality sediments. For metals (except mercury) and PAHs, average quality indexes were calculated.

The global status of the indicator is the proportion of uncontaminated sites and contaminated sites relative to the total number of sites characterized. This proportion defines an overall state between good and bad quality.

State of the St. Lawrence Monitoring Program

Five government partners—Environment and Climate Change Canada, Fisheries and Oceans Canada, Parks Canada, Quebec's Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques and the Ministère des Forêts, de la Faune et des Parcs—in collaboration with Stratégies Saint-Laurent, a non-governmental organization that works actively with riverside communities, are pooling their expertise and efforts to provide Canadians with information on the state of the St. Lawrence and its long-term changes. To this end, environmental indicators have been developed on the basis of data collected as part of each organization's ongoing environmental monitoring activities over the years. These activities cover the main components of the environment, namely water, sediments, biological resources, uses and shorelines. For more information on the State of the St. Lawrence Monitoring Program, please visit our website at www.planstlaurent.qc.ca/en.

Prepared by

Magella Pelletier
Fresh Water Quality Monitoring and Surveillance,
Environment and Climate Change Canada

Simon Blais
Environmental Protection Operations Directorate,
Environment and Climate Change Canada

Acknowledgments are extended to Michel Arseneau and Serge Lepage from Environment and Climate Change Canada for their contribution to the field work, and to Mélanie Desrosiers from the Centre d'Expertise en Analyse Environnementale du Québec, Lise Boudreau from the ministère du Développement durable, de l'Environnement et de la Lutte contre les Changements climatiques, and Donald St-Laurent, Myriam Rondeau, Nathalie Gratton, Caroline Savage, Martin Jean and François Boudreault from Environment and Climate Change Canada for their contribution to the production of the factsheet.

Bibliography

Environment Canada and Ministère du Développement durable, de l'Environnement et des Parcs du Québec. 2007. Criteria for the Assessment of Sediment Quality in Quebec and Application Frameworks: Prevention, Dredging and Remediation. 39 pages.

PASL, 1993. La contamination des sédiments de la zone portuaire de Québec, état de la situation et solutions envisagées Plan d'action Saint-Laurent, Division des programmes fédéraux, Direction de la protection Environnement Canada, ISBN 0-662-98497-8, 16 pages.

Pelletier M., M. Desrosiers, S. Lepage et Y. de Lafontaine, 2014, Butyltins in sediments of the St. Lawrence River, Information factsheet « Monitoring of the state of the St. Lawrence River », Environnement Canada, ISBN 978-0-660-21501-3, 7 pages.

Regoli L., H. M. Chan, Y. de Lafontaine et I. Mikaelian, 2001, Organotins in zebra mussels (Dreissena polymorpha) and sediments of the Quebec City Harbour area of the St. Lawrence River, Aquatic Toxicology 53 pp.115–126.

Saint-Louis R., M. Pelletier et S. Blais, 2014, Le rapport nickel/cobalt comme traceur de pollution associé aux activités de transbordement de minerai en zone portuaire, Presentation at 18th « Chapitre Saint-Laurent » conference, Québec (SETAC), June 6, 2014.

Cat. No.: En153-114/7-2017E-PDF
ISBN: 978-0-660-08699-6

© Her Majesty the Queen in Right of Canada,
represented by the Minister of Environment and Climate Change, 2018

Published by authority of Quebec's Minister of Sustainable Development, Environment and the Fight against Climate Change

© Government of Quebec, 2018

Également publié en français sous le titre :
Qualité des sédiments du fleuve Saint-Laurent dans le secteur de Québec en 2012 et son évolution depuis 1989.